

COOLING SYSTEM FOR ELECTRONICS WITH IMPROVED THERMAL INTERFACE

FIELD OF THE INVENTION

[0001] The present invention relates to a method and apparatus for a heat pipe system for removing heat from electronic equipment, and in particular, a heat pipe system for removing heat from a laptop computer.

DESCRIPTION OF THE RELATED ART

[0002] A basic heat pipe comprises a closed or sealed envelope or a chamber containing an isotropic liquid-transporting wick and a working fluid capable of having both a liquid phase and a vapor phase within a desired range of operating temperatures. When one portion of the chamber is exposed to relatively high temperature it functions as an evaporator section. The working fluid is vaporized in the evaporator section causing a slight pressure increase forcing the vapor to a relatively lower temperature section of the chamber defined as a condenser section. The vapor is condensed in the condenser section and returned through the liquid-transporting wick to the evaporator section by capillary pumping action.

[0003] Because it operates on the principle of phase changes rather than on the principles of conduction or convection, a heat pipe is theoretically capable of transferring heat at a much higher rate than conventional heat transfer systems. Consequently, heat pipes have been utilized to cool various types of high heat-producing apparatus, such as electronic equipment (See, e.g., U.S. Pat Nos. 5,884,693, 5,890,371, and 6,076,595).

[0004] Heat pipe assemblies are often used to remove heat from the Central Processing Unit (CPU) and other high power chips in computers. Maintenance of a good contact

between the CPU (or other chip) and the heat pipe assembly is essential for insuring good overall heat transfer.

[0005] Some conventional heat pipe assemblies create a contact between the CPU (or other chip) and a portion of the heat pipe through a heat transfer plate. Such heat transfer plates are disposed either above or below the CPU or chip, and are typically centered on the CPU or chip by guide members on the heat transfer plate which interface with guide members on the CPU or chip.

[0006] Most conventional heat transfer plates comprises metal blocks with at least one tunnel or recess therein for receiving a flattened end of the associated heat pipe. Figure 1 shows such a conventional heat pipe system 200. The heat pipe system 200 includes a heat transfer block 210, a heat pipe 220, and a heat dissipation structure 230. In a typical environment, such heat pipe system 200 would be disposed in proximity to a heat-producing apparatus (e.g. CPU, chip, etc.), such that the heat transfer block 210 would be in direct contact with the heat-producing apparatus. The heat transfer block 210 includes a tunnel 211 therein for receiving a flattened portion 221 of the heat pipe 220. The heat pipe 220 also includes a crimped end or 'pinchoff' portion 222 disposed at one end of the flattened portion 221. An end of the heat pipe 220 opposite the flattened portion 221 is coupled to the heat dissipation structure 230 (e.g., fin block). During manufacture of the heat pipe system shown in Figure 1, the flattened portion 221 of the heat pipe 220 is inserted into the tunnel 211 in the heat transfer block 210, and is secured therein.

[0007] Since this tunnel 211 in the heat transfer block 210 must be made large enough to receive the flattened end 221 of the heat pipe 220, and the pinchoff portion 222 of the heat pipe, the tunnel must be made at least as wide as the pinchoff. Since the pinchoff 222 is almost always wider than the flattened portion 221 of the heat pipe 220, the flattened portion of the heat pipe does not fit snugly in the tunnel 211, and thus, a poor

heat contact is created between the flattened portion of the heat pipe and the heat transfer block 210. Due to the poor heat contact between the flattened portion of the heat pipe 220 and the heat transfer block 210, maximum heat cannot be transferred from the CPU or chip to the heat pipe through the heat transfer plate.

[0008] Therefore, there is currently a need for a heat pipe system for effectively transferring maximum heat from a CPU (or other chip) to a heat pipe assembly in a computer.

SUMMARY OF THE INVENTION

[0009] The present invention is a heat pipe system including a heat transfer block and a heat pipe coupled to the heat transfer block by a clip.

[0010] The above and other advantages and features of the present invention will be better understood from the following detailed description of the exemplary embodiments of the invention which is provided in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0011] Figure 1 is a perspective view showing a conventional heat pipe system.

[0012] Figure 2 is a perspective view showing a heat pipe system according to a first exemplary embodiment of the present invention.

[0013] Figure 3 is a perspective view showing a magnified version of the heat pipe system shown in Fig. 2.

[0014] Figure 4 is a perspective view showing an exploded and magnified version of the heat pipe system shown in Fig. 2.

[0015] Figure 5 is a perspective view showing a heat pipe system according to a second exemplary embodiment of the present invention.

[0016] Figure 6 is a perspective view showing an exploded version of the heat pipe system shown in Fig. 5.

[0017] Figure 7 is a perspective view showing a heat pipe system according to a third exemplary embodiment of the present invention.

[0018] Figure 8 is a perspective view showing an enlarged of the heat pipe system shown in Fig. 7.

DETAILED DESCRIPTION

[0019] The present invention comprises an improved apparatus and method for transferring heat from a heat-producing electronic equipment (e.g., CPU or other computer chip) to a heat pipe through the use of a heat transfer plate. By attaching the

heat pipe to the heat transfer plate through a clip placed in the center of the heat transfer plate, maximum heat transfer from the heat transfer plate to the heat pipe can be achieved.

[0020] Referring to Figure 2, there is shown a heat pipe system 100 according to a first exemplary embodiment of the present invention. The heat pipe system 100 comprises a heat transfer block 110, a heat pipe 120, and a heat dissipation structure 130.

[0021] The heat transfer block 110 includes a channel 111 therein for receiving a flattened portion 121 of the heat pipe 120. The heat pipe 120 also includes a pinchoff portion 122 disposed at one end of the flattened portion 121. An end of the heat pipe 120 opposite the flattened portion 121 is coupled to the heat dissipation structure 130 (e.g., fin block). One end of the channel 111 of the heat transfer block 110 has a flared portion 112 for receiving the pinchoff portion 122 of the heat pipe 120. A clip member 140 overlies and secures the flattened portion 121 of the heat pipe 120 in the channel 111. It will be noted that the clip member 140 includes a main surface 141, and two side surfaces 142, 143 disposed orthogonal to the main surface. The main surface 141 primarily overlies the flattened portion 121 of the heat pipe 120, and the two side surfaces 142, 143 primarily reside in clip channels 113, when the clip 140 is coupled to the heat transfer block 110.

[0022] Figure 3 shows an enlarged view of the heat pipe 120 and heat transfer block 110 of the heat pipe system 100 according to the first exemplary embodiment of the present invention. It will be noted that the flattened portion 121 of the heat pipe is secured in the channel 111 of the heat transfer block 110 by the clip member 140.

[0023] Figure 3 explicitly shows that the two side surfaces 142, 143 of the clip are received in clip channels 113 formed in the heat transfer block 110. It will be noted that

although the clip channels 113 are formed as channels of a specific length which is less than the length of the transfer block 110, the clip channels may also be formed as full-length channels, such as channel 111. As will be understood by those skilled in the art, forming the clip channels 113 as full-length channels may reduce the expense of producing the heat transfer block 110 by allowing the transfer block to be formed completely by extrusion processes. The flattened portion 121 of the heat pipe 120 and the clip 140 may be secured in the channel 111 and the clip channels 113 respectively by fasteners (e.g., screws, bolts, stakes, rivets, etc.), solder, epoxy or other known materials.

[0024] Alternatively, the flattened portion 121 of the heat pipe 120 and the clip 140 may be secured in the channel 111 and the clip channels 113 by the surface friction of the flattened portion and the clip 140 against the walls of the channel 111 and the clip channels 113. In order to accomplish a tight friction contact between the channel 111 and the flattened portion 121 of the heat pipe 120, the channel is made only slightly wider than the flattened portion, so that the flattened portion fits snugly in the channels. To effect a tight friction contact between the clip 140 and the clip channels 113, the side surfaces 142, 143 of the clip are splayed out (i.e., away from the main surface) slightly, so that the side surfaces of the clip are urged against the clip channel walls when the clip is disposed in the heat transfer block 110.

[0025] The heat transfer block 110 also includes guide members 114 with openings 115 formed therein for securing the heat transfer block to a CPU or chip. Typically, a CPU or chip will include complementary guide members, such as posts, which may be received in the openings 115 in order to secure the heat transfer block 110 to the CPU or chip.

[0026] The above-described heat pipe system 100 may be formed by various methods. For example, the heat transfer block 110 may be formed as a single substantially uniform part which is later milled to create the heat pipe channel 111 and clip channels 113. Once

the milled part has been manufactured, the heat pipe 120 and clip 140 may be bonded to the heat transfer block 110 by the methods discussed above (e.g., solder, epoxy, friction, fasteners), or by other means known to those skilled in the art. Alternatively, the heat transfer block 110 may be formed with the heat pipe channel 111 and the clip channels 113 already formed therein, by a process such as extrusion.

[0027] Since, in the present invention, the flattened portion 121 of the heat pipe 120 fits tightly within the channel 111 in the heat transfer block 110, and is further secured using clip 140, maximum heat transfer from the heat transfer block to the heat pipe can be achieved. As explained above, in conventional heat pipe systems such maximum heat transfer could not be realized due to the fact that the flattened portion of the heat pipe did not fit snugly within the channel (See Fig. 1). Thus, the present invention it is submitted that the present invention represents a significant advance in heat transfer technology.

[0028] Figure 4 shows an enlarged and exploded view of the heat pipe 120 and heat transfer block 110 of the heat pipe system 100 according to the first exemplary embodiment of the present invention. Figure 4 clearly shows that the channel 111 includes a flared portion 112 which is wider than the rest of the channel. As stated above, this flared portion 112 operates to receive the pinchoff portion 122 of the heat pipe 120. Figure 4 also clearly shows the clip channels 113. Although the clip channels 113 are oval-shaped in Figure 4, it will be understood that these channels may take various geometrical shapes (e.g., rectangles, etc.).

[0029] One of the main reasons for utilizing the channel structure 111 described above is to provide a means of applying downward pressure on the heat transfer block 110. The downward pressure must be applied at the physical center of the CPU or chip to which the transfer block 110 is coupled to assure that the transfer block is seated squarely on the CPU or chip without creating a gap therebetween. Often times when the transfer block

110 is not seated squarely on the CPU or chip a wedge-shaped gap is formed between the transfer block and the CPU or chip. Such a gap could result in poor thermal contact between the CPU or chip and the transfer block 110, and could, in the case of a CPU having an exposed silicon die, cause cracking or splaying from the edges of the die, and subsequently reduce heat transfer area or cause electrical malfunction. The downward pressure cannot be applied through the wall of the heat pipe because the wall is often made of a thin metal (e.g., Copper) sheet which does not have sufficient tensile strength to transfer the force without deformation of the metal. Such deformation may result in diminution of the contact pressure, and reduction in heat pipe performance due to the local reduction in vapor flow area. The channel structure 111 is designed to circumvent the deformation problem, while allowing pressure to be applied at the center of the CPU or chip to which the transfer block 110 is coupled.

[0030] Additionally, in the first exemplary embodiment described above, the heat pipe 120 is disposed at the physical center of the CPU or chip, the region of maximum heat production. Location of the heat pipe 120 in this region produces a heat pipe system 100 with a low thermal resistance.

[0031] Referring to Figure 5, there is shown a heat pipe system 300 according to a second exemplary embodiment of the present invention. Similar to the heat pipe system 100, the heat pipe system 300 includes a heat transfer block 310, a heat pipe 320, and a heat dissipation structure (not shown). However, the heat pipe system 300 includes only a single clip channel 313 for receiving a clip 340.

[0032] Figure 5 shows that the heat transfer block 310 includes a channel 311 therein for receiving a flattened portion 321 of the heat pipe 320. The heat pipe 320 also includes a pinchoff portion 322 disposed at one end of the flattened portion 321. An end of the heat pipe 320 opposite the flattened portion 321 is coupled to the heat dissipation structure

(not shown). One end of the channel 311 of the heat transfer block 310 has a flared portion 312 for receiving the pinchoff portion 322 of the heat pipe 320. A clip member 340 overlies and secures the flattened portion 321 of the heat pipe 320 in the channel 311. It will be noted that the clip member 340 includes a main surface 341, and two side surfaces 342, 343 disposed orthogonal to the main surface. The main surface 341 primarily overlies the flattened portion 321 of the heat pipe 320, and the two side surfaces 342, 343 primarily reside in single clip channel 313, when the clip 340 is coupled to the heat transfer block 310.

[0033] It will be noted that the two side surfaces 342, 343 of the clip are received in a single clip channel 313 formed in the heat transfer block 310. The flattened portion 321 of the heat pipe 320 and the clip 340 may be secured in the channel 311 and the single clip channel 313 respectively by fasteners (e.g., screws, bolts, etc.), solder, epoxy or other known materials.

[0034] Alternatively, the flattened portion 321 of the heat pipe 320 and the clip 340 may be secured in the channel 311 and the single clip channel 313 by the surface friction of the flattened portion and the clip 340 against the walls of the channel 311 and the single clip channel 313. As stated above with respect to the first exemplary embodiment, in order to accomplish a tight friction contact between the channel 311 and the flattened portion 321 of the heat pipe 320, the channel is made only slightly wider than the flattened portion, so that the flattened portion fits snugly in the channels. To effect a tight friction contact between the clip 340 and the single clip channel 313, the side surfaces 342, 343 of the clip are splayed out (i.e., away from the main surface) slightly, so that the side surfaces of the clip are urged against the clip channel walls when the clip is disposed in the heat transfer block 310.

[0035] The heat transfer block 310 also includes guide members 314 with openings 315 formed therein for securing the heat transfer block to a CPU or chip. Typically, a CPU or chip will include complementary guide members, such as posts, which may be received in the openings 315 in order to secure the heat transfer block 310 to the CPU or chip.

[0036] As described above with reference to the heat pipe system 100 of the first exemplary embodiment, the heat pipe system 300 may be formed by various means such as milling and extrusion.

[0037] Referring to Figures 7 and 8, there is shown a heat pipe system 400 according to a second exemplary embodiment of the present invention. Similar to the heat pipe system 100, the heat pipe system 400 includes a heat transfer block 410, a heat pipe 420, and a heat dissipation structure 430. However, the heat pipe system 400 includes a flattened clip member 440 which extends across the heat transfer block 410 with tabs 441, 442 formed therein for being received in respective channels 451, 452 of the heat transfer block (See Fig. 8).

[0038] Figure 7 shows that the heat transfer block includes a channel 411 therein for receiving a flattened portion 421 of the heat pipe 420. A clip member 440 overlies and secures the flattened portion 421 of the heat pipe 420 in the channel 411. It will be noted that the clip member 440 includes a top surface 445, and a bottom surface 446 with tabs 441, 442 extending orthogonally therefrom (See Fig. 8).

[0039] The flattened portion 421 of the heat pipe 420 and the clip 440 may be secured in the channel 411 and the clip channels 451, 452 respectively by fasteners (e.g., screws, bolts, etc.), solder, epoxy or other known materials.

[0040] Alternatively, the flattened portion 421 of the heat pipe 420 and the clip 440 may be secured in the channel 411 and the clip channels 451, 452 by the surface friction of the flattened portion and the clip 440 against the walls of the channel 411 and the clip channels 451, 452. As stated above with respect to the first exemplary embodiment, in order to accomplish a tight friction contact between the channel 411 and the flattened portion 421 of the heat pipe 420, the channel is made only slightly wider than the flattened portion, so that the flattened portion fits snugly in the channels. Similarly, to effect a tight friction contact between the clip 440 and the clip channels 451, 452, the channels are made only slightly wider than the respective tabs 441, 442.

[0041] The heat transfer block 410 also includes guide members 414 with openings 415 formed therein for securing the heat transfer block to a CPU or chip. Typically, a CPU or chip will include complementary guide members, such as posts, which may be received in the openings 415 in order to secure the heat transfer block 410 to the CPU or chip.

[0042] As described above with reference to the heat pipe system 100 of the first exemplary embodiment, the heat pipe system 400 may be formed by various means such as milling and extrusion.

[0043] Although the invention has been described in terms of exemplary embodiments, it is not limited thereto. Rather, the appended claims should be construed broadly, to include other variants and embodiments of the invention which may be made by those skilled in the art without departing from the scope and range of equivalents of the invention.